REMARKS/ARGUMENTS

This case has been reviewed and analyzed in view of the Official Action dated 10 December 2004. Responsive to the rejections made by the Examiner in the outstanding Official Action, Claims 1 and 9 have been amended and claims 5, 8 and 11 have been cancelled in order to more clearly clarify the inventive concept of the Applicant.

Prior to a discussion of the Examiner's objections and rejections made in the outstanding Official Action, it is believed that it may be beneficial to briefly review the subject Patent Application system in light of the inventive concept of the Applicant. The subject Patent Application is directed towards a rotor blade system for reducing blade-vortex interaction noise and a method of reducing blade vortex interaction noise in the rotor blade system. As shown in the subject Patent Application drawings, at least one tube member is formed within the rotor blade, with the tube member having an inlet located above the leading edge of the rotor blade and having an outlet located at the rotor blade tip face. The positioning of the inlet above the leading edge is necessary for maximizing the attenuation of flow velocities within the vortex core. The tube members are positioned within the rotor blades such that a portion of incident flow is directed from the leading edge through the tube members and is ejected from the rotor blade tip face such that a tip vortex is detached from the rotor blade tip base and turbulent vortlets are

introduced within a laminar core of a developing vortex for dissolving the laminar core and reducing blade-vortex interaction noise. The inlet is shaped and positioned in order to maximize attenuation of flow velocities within the vortex core.

The Examiner has rejected Claims 1, 4 – 6, 8, 9 and 11 under 35 U.S.C. § 103(a) as being unpatentable over the Crimi Patent No. 4,045,146 in view of the Azuma Patent No. 5,562,414. It is the Examiner's contention that it would have been obvious at the time of the invention to modify the rotor blade system with reduced blade-vortex interaction noise of Crimi with the outlet located at the rotor blade tip as taught by Azuma for the purpose of blowing the blade tip vortex away from the tip, thus providing a noise reduction device for rotor-craft.

It is respectfully submitted that the systems of Crimi and Azuma, whether taken alone or in combination, operate in view of different physics principles than the subject application, different positional element relationships than the subject application system, and although trying to reduce "vortex noise", they try to accomplish such in a totally different manner than that provided in the subject application.

The Crimi reference is directed towards a helicopter rotor blade. As shown in Figure 1, the rotor blade B is mounted on a shaft s via a hub H and comprises as a boundary layer control segment a sucking inlet region I located with its center at a radial location on the blade R_c over a control length l_c, sucking air into an

internal duct D of the blade and exhausting it out of the portion E_1. Figure 3 illustrates the exhaust of the centrifugal pumping passage wherein the exhaust end of the duct D is indicated at E-1 and trails behind the blade tip T to be immersed in the tip vortex.

The Crimi reference suggests a flow jet be established through the pumping action of centrifugal force. This requires a lengthy tube in order to forcefully discharge the accelerated flow within the wake or entrain the boundary layer flow on the upper surface of the blade near the leading edge region in order to reduce the possibility of blade stall and increase forward speed.

The Azuma reference is directed towards a noise reduction device for rotorcraft. As shown in Figures 1 and 2, the rotor blade 1 contains an air supply passage 3 to supply compressed air furnished from a fuselage 2 toward the rotor blade tip. Air ejecting nozzle 6a and 6b are equipped with compressed air ejection angle control device 5 on the blade tip 4a and on trailing edge 4b near the blade tip.

The Azuma reference uses compressed air exhaust delivered into the tip face to detach the tip vortex from the tip face.

In contradistinction, the system and method of the subject Patent Application relies on a specific geometrical placement of the inlet and outlet of the slots in order to produce the necessary pressure gradient to cause a small amount of incident flow into the tip face. The location of the slot outlet is designed to

encourage the turbulent flow to become entrained into the laminar core of the blade tip vortex. This enhances turbulent diffusion inside the vortex core and dissipates the velocity intensity of the vortex. It should be noted that this effect is not produced by any external power source.

The Azuma reference, even when taken in combination with the Crimi reference, pushes the tip vortex to become detached from the blade tip or changes the position of the tip vortex relative to the blade and the rotor. This, however, results in the vortex trail being pushed up but still having the chance to linger in the rotor plane of the helicopter during fast forward flight. In order to get enough separation distance between the vortex and the blade, this would require a very high jet flow velocity, which would result in a significant use of power expenditure.

Further, the Crimi reference utilizes a pumped air exhaust source in order to break or alleviate the tip vortex. The reference teaches a blowing jet produced by centrifugal force which is exhausted at the inboard trailing edge of the blade and not at the tip face. The jet that is exhausted in the direction of the wake at a fixed location cannot be inserted into the core trail of the tip vortex and distorts or modifies only the structure of the rolled-up vortex envelope.

In the system of the subject Patent Application, modifications to the vortex structure are made at the origin of the vortex roll-up which is a much more

effective means of changes a vortex structure and reduces its effects on blade loads and noise.

Further, it is reiterated that both the Azuma reference and the Crimi reference, when taken alone or in combination, provide for a significant power expenditure on the part of the helicopter or other aircraft in order to provide for reduction of vortex-related noise.

Thus, neither the Crimi reference nor the Azuma reference, when taken alone or in combination, provide for: "... said at least one or any tube member having an inlet located above said leading edge ... wherein said at least one tube member being positioned within said at least one rotor blade such that a portion of incident flow is directed from said leading edge through said at least one tube member and is ejected from said rotor blade tip face whereby a tip vortex is detached from said rotor blade tip face and turbulent vortlets are introduced within a laminar core of a developing vortex for dissolving said laminar core and reducing blade-vortex interaction noise, said inlet being shaped and positioned to maximize attenuation of flow velocities within the vortex core ...", as is clearly provided by newly-amended independent Claim 1. Further, neither the Azuma reference nor the Crimi reference, when taken alone or in combination, provide for: "... said at least one tube member having an inlet thereof positioned above said leading edge portion ... wherein said at least one tube member being positioned within said at least one rotor blade such that a portion of incident flow

is directed from said leading edge through said at least one tube member and is ejected from said rotor blade tip face whereby a tip vortex is detached from said rotor blade tip face and turbulent vortlets are introduced within a laminar core of a developing vortex for dissolving said laminar core and reducing blade-vortex interaction noise, said inlet being shaped and positioned to maximize attenuation of flow velocities within the vortex core ...", as is clearly provided by newly-amended independent Claim 9.

Thus, based upon independent Claims 1 and 9, it is now believed that the subject Patent Application is made obvious by either the Azuma reference or the Crimi reference, when taken alone or in combination.

The Examiner has further rejected Claims 2, 3 and 10 under 35 U.S.C. § 103(a) as being unpatentable over the Crimi reference in view of the Azuma reference, and further in view of the Examiner's contention of the subject system and method being a "design choice". It is the Examiner's contention that it would have been an obvious matter of design choice to a person of ordinary skill in the art to duplicate the tube member in quantity of four because the Applicant has not disclosed the duplicating tube members provides an advantage, or is used for a particular purpose, or solves a stated problem.

As noted above, with regard to the rejection of Claims 1, 4-6, 8, 9 and 11, the Crimi reference, even taken in combination with the Azuma reference, does not rely on a specific geometrical placement of the inlet and outlet of the slots in

order to produce a necessary pressure gradient to cause a small amount of incident flow into the tip face. The location of the slot outlets in the subject Patent Application system is designed to encourage the turbulent flow to become entrained into the laminar core of the blade tip vortex. This enhances turbulent diffusion inside the vortex core and dissipates the velocity intensity of the vortex.

The geometry of the vented slot in the subject Patent Application system, which is shaped as a quarter-circle with its inlet located on the upper surface of the leading edge of the blade tip, is the optimized configuration not only for minimum rotor power but for maximizing the attenuation of the flow velocities inside the vortex core. The flow is not accelerated by centrifugal force, such as in the Crimi reference, but is optimized based on the pressure gradients between the inlet and outlet of the slots. The low pressure at the outlet requires the inlet to be located on the upper surface of the blade, which controls the net pressure gradient. This design requires no changes to the external shape of the blade and, thus, would have no impact on other aspects of helicopter performance, such as the weight carried, the forward speed, etc.

Additionally, the virtual envelope produced by the vortex roll-up has an approximately conical shape over the cord on the tip face. Therefore, the distributed slot exits (or outlets) need different pressure gradients and different flow rates. In the preferred embodiment, the system of the subject Patent Application utilizes four different exit locations in order to establish the optimal

and most effect break-up of the strong laminar vortex core. The closest slot from the leading edge of the tip face has the maximum incident flow because its entrance locates at the longest rotor radius and has the shortest tube length. Therefore, through this exit, the strongest turbulent vortlet comes in the weakest virtual core, but the exiting flow through this shortest tube has the weakest angular effect to the spanwise direction because the momentum of the incident flow still dominates in the wake direction. Likewise, through the farthest exit, the weakest vortlet is inserted into the strongest vortex part of the core, but has the best angularity to the tip face. Through these four slots, an ideally distributed strength over the tip face of the turbulent vortlets is obtained.

These aspects are in total and complete contradistinction from the Azuma design, which includes no control of the discharge of the air in the chord-wise direction (along the tip face). The system of the subject Patent Application is provided not just to meet a flow rate requirement to detach the vortex or move it away from the blade, but additionally to control the discharge of the air for optimized operational conditions.

Further, in the system of the subject Patent Application, by locating the slot inlets above the leading edge (i.e. on the suction surface), the pressure gradients are controlled between the inlet and the outlet of the slots, thus controlling the flow rate through the slots. A high flow rate through the slots, such as would be required in the system of the Crimi patent, is <u>not</u> the most effective approach for

changing the structure of the tip vortex core, and the system of the subject Patent Application relies on a low flow rate but one with sufficient energy to eject the necessary turbulent flow directly into the otherwise laminar core of the evolving vortex.

Additionally, the multiplicity of slots (ideally, four in the preferred embodiment) of the system of the subject Patent Application provides optimal vortex diffusion and it should be noted that both Crimi and Azuma utilize a single slot.

Through the suitable selection of the geometry and positioning of the slots, the system of the subject Patent Application is able to diffuse the vortex core and reduce vortex induced velocities, reduce unsteady blade loads and noise and simultaneously minimize adverse effects on rotor performance. All of these advantages are carried out with a minimum of additional power expenditure, unlike both the Crimi system and the Azuma system.

Thus, neither the Crimi reference nor the Azuma reference, when taken alone or in combination, provide for: "... said at least one or any tube member having an inlet located above said leading edge ... wherein said at least one tube member being positioned within said at least one rotor blade such that a portion of incident flow is directed from said leading edge through said at least one tube member and is ejected from said rotor blade tip face whereby a tip vortex is detached from said rotor blade tip face and turbulent vortlets are introduced within

a laminar core of a developing vortex for dissolving said laminar core and reducing blade-vortex interaction noise, said inlet being shaped and positioned to maximize attenuation of flow velocities within the vortex core ...", as is clearly provided by newly-amended independent Claim 1. Further, neither the Azuma reference nor the Crimi reference, when taken alone or in combination, provide for: "... said at least one tube member having an inlet thereof positioned above said leading edge portion ... wherein said at least one tube member being positioned within said at least one rotor blade such that a portion of incident flow is directed from said leading edge through said at least one tube member and is ejected from said rotor blade tip face whereby a tip vortex is detached from said rotor blade tip face and turbulent vortlets are introduced within a laminar core of a developing vortex for dissolving said laminar core and reducing blade-vortex interaction noise, said inlet being shaped and positioned to maximize attenuation of flow velocities within the vortex core ...", as is clearly provided by newly-amended independent Claim 9.

Thus, it is not believed that the subject Patent Application is made obvious by either the Crimi reference or the Azuma reference, or design choice, when taken alone or in combination, when independent Claims 1 and 9 are carefully reviewed.

The Examiner has further rejected Claim 7 under 35 U.S.C. § 103(a) as being unpatentable over the Crimi reference in view of Azuma and further in view

of design choice. It is the Examiner's contention that it would have been an obvious matter of design choice to a person of ordinary skill in the art to make the rotor blade with the distance between outlets approximately 0.157 of the chord of the rotor blade tip, and wherein the diameter of each tip member is approximately 0.067 of said chord because the Applicant had not disclosed that making the outlets at location as claimed provides an advantage, is used for a particular purpose, or solves a stated problem.

As described above with regard to the rejection under Claims 2 – 3 and 10, the geometry of the vented slot, and the positioning thereof, is necessary to the proper functioning of the device of the subject Patent Application. Further, the size of the tube diameter was selected at 0.067 of the chord only to maximize the attenuation of the flow velocities inside the vortex core but further in order to realistically be built into the blade tip. The distance between outlets and the positions of the inlet (on the upper, suction surface) and outlet (distributed along the side edge of the blade tip) was selected to get the proper pressure gradient and distribution of flow rate and provide for optimal generation of turbulent vortlets which can be entrained into the tip vortex core.

Thus, neither the Crimi reference nor the Azuma reference, when taken alone or in combination, provide for: "... said at least one or any tube member having an inlet located above said leading edge ... wherein said at least one tube member being positioned within said at least one rotor blade such that a portion of

incident flow is directed from said leading edge through said at least one tube member and is ejected from said rotor blade tip face whereby a tip vortex is detached from said rotor blade tip face and turbulent vortlets are introduced within a laminar core of a developing vortex for dissolving said laminar core and reducing blade-vortex interaction noise, said inlet being shaped and positioned to maximize attenuation of flow velocities within the vortex core ...", as is clearly provided by newly-amended independent Claim 1. Further, neither the Azuma reference nor the Crimi reference, when taken alone or in combination, provide for: "... said at least one tube member having an inlet thereof positioned above said leading edge portion ... wherein said at least one tube member being positioned within said at least one rotor blade such that a portion of incident flow is directed from said leading edge through said at least one tube member and is ejected from said rotor blade tip face whereby a tip vortex is detached from said rotor blade tip face and turbulent vortlets are introduced within a laminar core of a developing vortex for dissolving said laminar core and reducing blade-vortex interaction noise, said inlet being shaped and positioned to maximize attenuation of flow velocities within the vortex core ...", as is clearly provided by newly-amended independent Claim 9.

Thus, it is not believed that the subject Patent Application is made obvious in view of the Crimi reference or the Azuma reference, when taken alone or in combination, when independent Claims 1 and 9 are carefully reviewed.

It is now believed that the remaining claims 2 – 4, 6, 7, and 10 show patentable distinction over the prior art cited by the Examiner for at least the same reasons as those previously discussed for independent Claims 1 and 9.

The remaining references cited by the Examiner, but not used in the rejection, have been reviewed, but are believed to be further removed when patentable distinctions are taken into account than those cited by the Examiner in the rejection.

It is now believed that the subject Patent Application has been placed in condition for allowance, and such action is respectfully requested.

Respectfully submitted,
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